CLAIMS

1. A fuel cell, comprising:

a renewable active metal anode;

a cathode structure comprising a electronically conductive component, an ionically conductive component, and a fluid oxidant;

an ionically conductive protective membrane on the first surface of the anode, the membrane comprising,

one or more materials configured to provide a first surface chemically compatible with the active metal of the anode in contact with the anode, and a second surface substantially impervious to and chemically compatible with the cathode structure and in contact with the cathode structure.

2. The cell of claim 1, wherein the ionically conductive protective membrane comprises a composite, the composite comprising,

a first material component in contact with the anode that is ionically conductive and chemically compatible with the active metal of the anode; and

a second material component in contact with the first material component, the second material being substantially impervious, ionically conductive and chemically compatible with the first material component and the cathode structure.

3. The cell of claim 1, wherein the ionic conductivity of the protective membrane is at least 10^{-5} S/cm.

4. The cell of claim 1, wherein the cathode oxidant comprises air.

5. The cell of claim 1, wherein the cathode oxidant comprises water.

6. The cell of claim 1, wherein the cathode oxidant comprises hydrogen peroxide.

7. The cell of claim 1, wherein the protective membrane is a composite laminate.

8. The cell of claim 1, wherein the protective membrane is a graded composite.

9. The cell of claim 1, wherein the active metal of the anode is lithium or a lithium alloy.

10. The cell of claim 2, wherein the first component comprises a material selected from the group consisting of active metal nitrides, active metal phosphides, and active metal halides, and active metal phosphorus oxynitride glass.

11. The cell of claim 2, wherein the first layer comprises a material selected from the group consisting of Li_3N, Li_3P and LiI, LiBr, LiCl, LiF, and LiPON.

12. The cell of claim 2, wherein the second component comprises a material selected from the group consisting of glassy or amorphous metal ion conductors, ceramic active metal ion conductors, and glass-ceramic active metal ion conductors.

13. The cell of claim 2, wherein the second component is an ion conductive glass-ceramic having the following composition:

Composition	mol %
P_2O_5	26-55%
SiO_2	0-15%
$GeO_2 + TiO_2$	25-50%
in which GeO_2	0—50%
TiO_2	0—50%
ZrO_2	0-10%
M_2O_3	0 < 10%
Al_2O_3	0-15%
Ga_2O_3	0-15%
Li_2O	3-25%

and containing a predominant crystalline phase composed of $Li_{1+x}(M,Al,Ga)_x(Ge_{1-y}Ti_y)_{2-x}(PO_4)_3$ where $X \leq 0.8$ and $0 \leq Y \leq 1.0$, and where M is an element selected from the group consisting of Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Yb and/or and $Li_{1+x+y}Q_xTi_{2-x}Si_yP_{3-y}O_{12}$ where $0< X \leq 0.4$ and $0< Y \leq 0.6$, and where Q is Al or Ga.

14. The cell of claim 1, wherein the anode comprises solid state lithium metal.

15. The cell of claim 1, wherein the anode comprises lithium metal dissolved in a suitable solvent.

16. The cell of claim 15, wherein the solvent is selected from the group consisting of hexamethyl phosphoramide (HMPA), ammonia, organic amides, amines and combinations thereof.

17. The cell of claim 15, wherein the solvent comprises hexamethyl phosphoramide (HMPA).

18. The cell of claim 15, wherein the solvent comprises methylamine.

19. The cell of claim 1, wherein the cell is operated such that the anode is supplemented by fresh lithium metal, as required to provide continuous operation for as long as desired.

20. The cell of claim 14, wherein the anode is supplemented by fresh lithium metal by contacting the existing lithium of the anode with additional lithium having a lithium bonding coat such that the additional lithium bonds to the original lithium.

21. The cell of claim 20, wherein the bonding coat is Ag or other lithium-alloying metal.

22. The cell of claim 15, wherein bulk lithium metal is fed to the solution keeping the solution near or at the lithium solubility limit.

23. The cell of claim 5, further comprising a PEM H_2/O_2 fuel cell to capture hydrogen released in the fuel cell redox reaction.